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AUTHOR Burroughs, J. A.; And Others
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ABSTRACT

This paper extends previous numerical results of the Flexible Equal Employment Opportunity (FEEO) model, a goal programing model (developed by A. Charnes, W. W. Cooper, K. A. Lewis, and R. J. Niehaus) consisting of Markoff transition elements imbedded in a goal programing framework with priorities that allow for element alteration to provide the organizational flexibility (in policies of promotion, recruitment, and training) necessary to achieve long-range equal employment opportunity (EEO) goals while still preserving the high priority of meeting the shorter range day-to-day operating goals of the organization. In the first section of the paper EEO goal-setting procedures are documented. Focus is on demographic considerations (making goals realistic from the labor market point of view) and upward mobility (consideration of affirmative action policies for the internal staff). A second section provides a numerical example with actual Navy data of the extended version of the model through which internal promotion and upward mobility considerations can be evaluated explicitly. A discussion is then provided of the implementation and continuing research possibilities. (JT)

RESEARCH REPORT NO. 29

Demographic And Upward Mobility Considerations In Using An Equal Employment Opportunity Model

by

J. A. Burroughs*
S. Korn**
K. A. Lewis***
R. J. Niehaus*

*U. S. Navy Office of Civilian Personnel
**Naval Underwater Systems Center
***School of Urban and Public Affairs, Carnegie-Mellon University

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INTRODUCTION

Equal Employment Opportunity (EEO) implies a systematic approach to filling jobs with qualified individuals whatever their background. This approach includes providing appropriate consideration both to the current workforce composition and to that of the surrounding labor force and applicant pool. In this process the creation of new jobs (including training) or the provision of procedures that establish "bridge positions" between particular types of jobs may be necessary so that individuals of all "social" groups have a chance to rise through the organizational system. The ultimate goal of EEO planning is to eliminate the need for special attention to insure equity in employment decisions.

The first step in the development of effective management tools for EEO planning was the determination of the extent of the current EEO problem. This was followed by the development of a goal programming model by Charnes, Cooper, Lewis, and Niehaus [3]. This model, consisting of Markoff transition elements imbedded in a goal programming framework is called the Flexible Equal Employment Opportunity (FEEO) model, because of its properties that allow for element alteration to provide the organizational flexibility (in policies of promotion, recruitment and training) necessary to achieve long-range EEO goals. These long-range goals are met "as closely as possible" while still preserving the high priority of meeting the shorter-range day-to-day operating goals of the organization.

A limited version of the EEO model without the flexibility features was subsequently tested with actual Navy data as discussed by Burroughs and Niehaus [1]. These tests proved successful and formed the basis of the

specifications for a comprehensive EEO model and control system. This system concept was endorsed by the Assistant Secretary of the Navy (Manpower and Reserve Affairs). Steps are now in process to obtain concurrence of the Navy's major commands, which in the end are accountable for conformance with Federal and Department of Defense policies. Thus, the limited form of the model has passed from research into a comprehensive program implementation.

One purpose of this paper is to document in more detail the EEO goal-setting procedures. Another is to provide an initial numerical example with actual Navy data of the version of the model which includes the flexibility features. This is followed by a discussion of implementation and research possibilities with the improved prototype in hand.

A parallel but integral part of these EEO model studies is the development of decision tools for the local installation commanding officer. Because of the instabilities of the small populations in some job categories at the local level, another type of model appears necessary. A model called a "coherence" model has been postulated for this purpose. The details of this model can be found in Charnes, Cooper, Lewis, and Niehaus [2]. We will turn now to the problems of goal-setting and the numerical example of the flexible version of the initial EEO model, which was designed for policy planning and control.

Demographic Considerations in Goal Setting

Irrespective of the method of planning and analysis, attention must be paid to setting realistic EEO goals. The current Navy EEO goals policy is discussed in [13]. Essentially this policy states that the EEO goals should be set on the basis of a social group's (i.e., ethnic-sex combination)

representation in the population or recruitment area. The first tests of the EEO model without internal upward mobility adjustments showed that one must consider the supply by occupation and career level if the results are to be realistic and meaningful. These prototypes, however, were only a beginning in the development of the procedures for the enumeration of the EEO goals in light of the labor markets involved. In this section of this paper we will provide a more comprehensive methodology for the goal setting process.

In [1], the assumptions supporting the method of realistic numerical goal determination by the DON are provided. The goals are defined in several stages over a fifteen year time frame (1976-1991), with intermediate goals being generated at several points in time for eight social groups across six major job categories. Both the current on-board population and the external labor market are considered in determining the goals. Such factors as social group representation, occupation educational requirements, occupational choice, and career progression are all taken into account.

The procedure used in setting goals is outlined in Figure 1. The manpower requirements reflect the workload of the organization irrespective of EEO considerations. These manpower requirements are split into EEO goals via the goal calculation program. The input to this algorithm is derived by first looking at the several social groups' representation within the labor market. These statistics are modified based on the current on-board population, but with a slight bias to ensure that affirmative action will help to drive towards the desired ratios. The supply ratios resulting from the labor market analysis are entered into the goal calculation program.

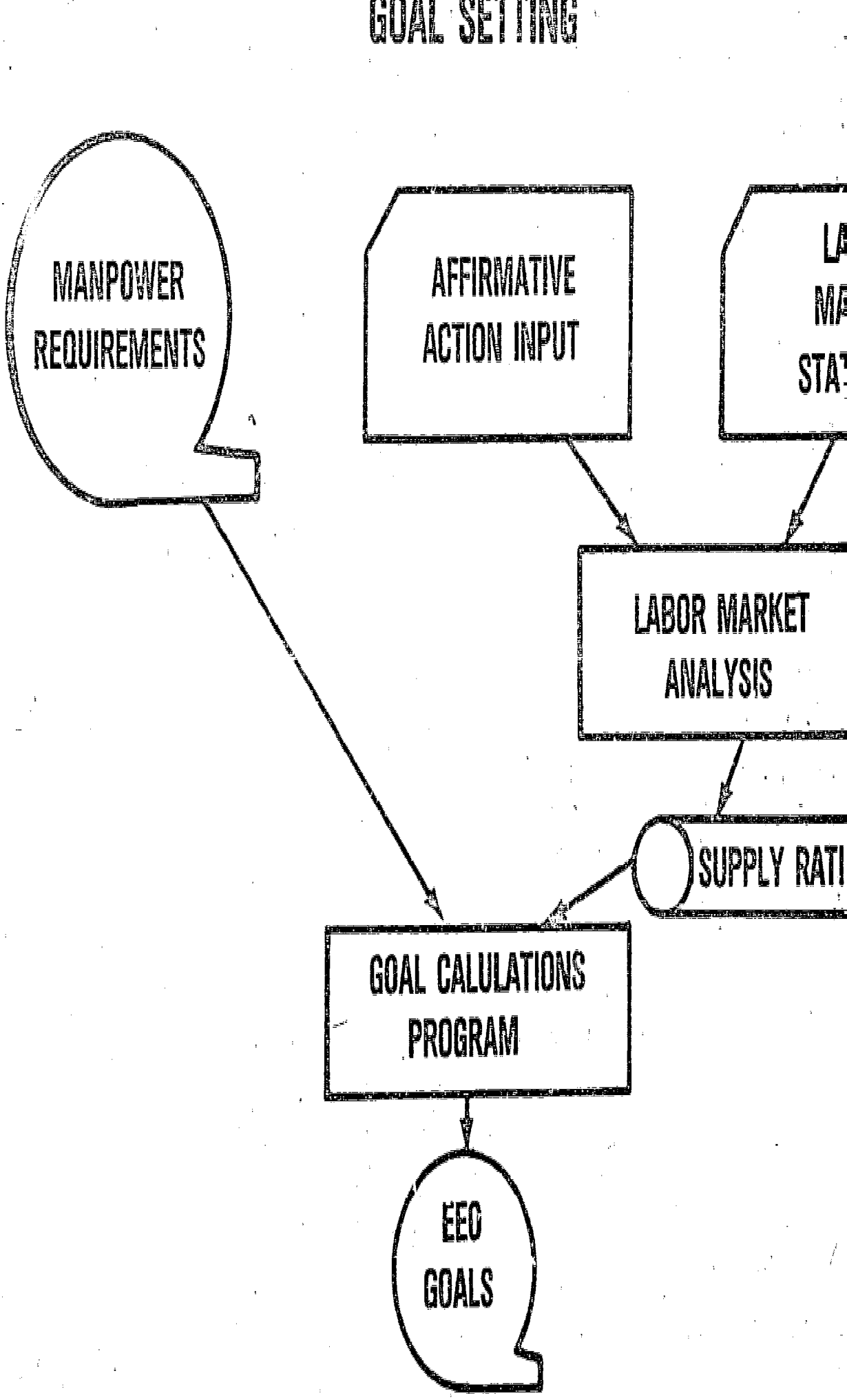
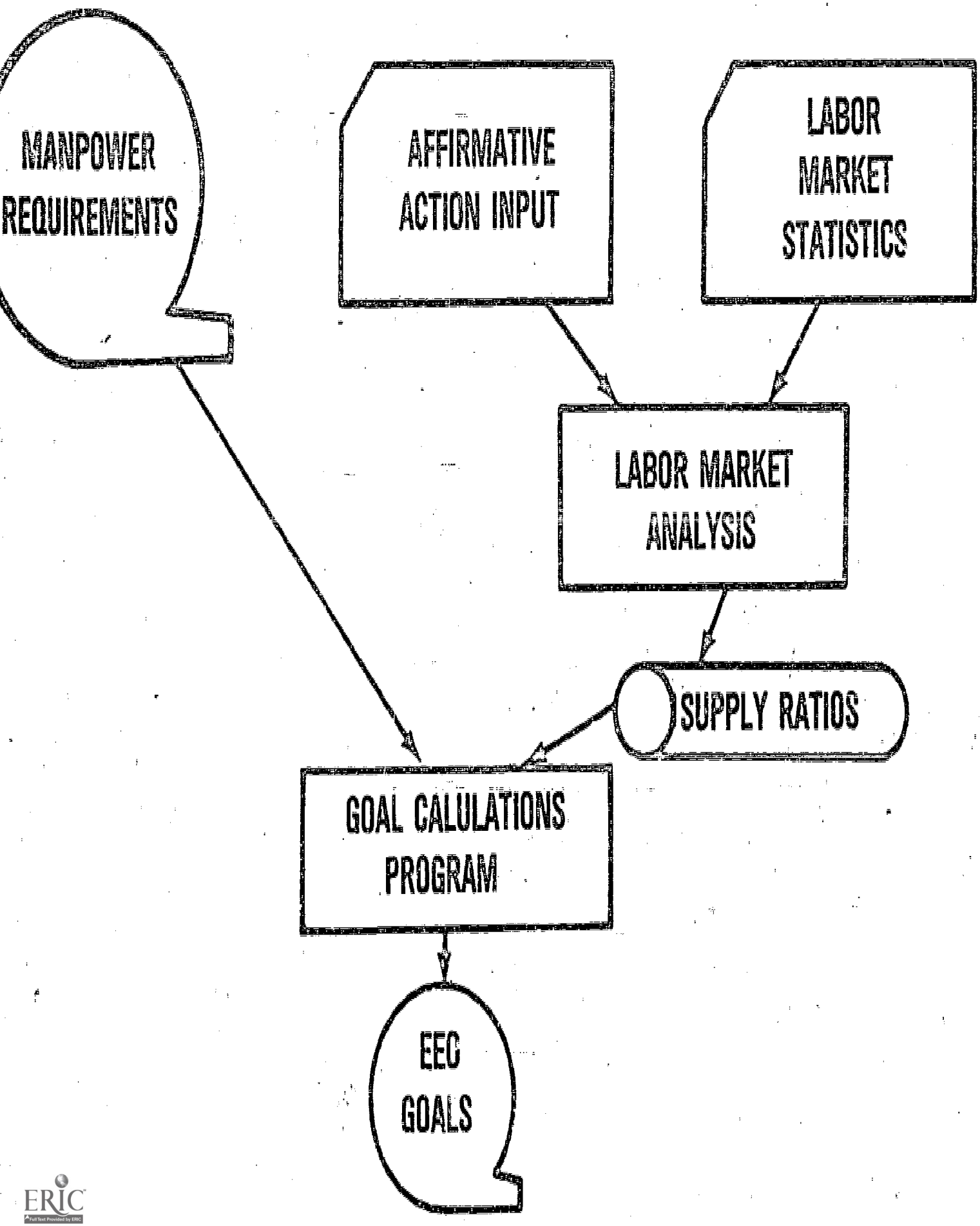

GOAL SETTING
MANPOWER REQUIREMENTS
AFFIRMATIVE ACTION INPUT
LABOR MARKET ANALYSIS
SUPPLY RATI
GOAL CALULATIONS PROGRAM
EEO GOALS

Figure 1

GOAL SETTING



This goal calculation first develops the goal at the end point of the plan. Then the intermediate goals are determined by a straight line interpolation between the starting population and the goal at the end point.

An example of this goal calculation might be for Black Male Scientists and Engineers at the GS 9-12 level. Let

$X_{ik}(t)$ = numerical goal for occupation/level state i, social class k, time t ($0 < t \leq 5$)

That is for this example, i = 2/3 (2=Scientists and Engineers/ 3=GS 9-12 level), k=2 (Black Male), and t=5

$X_{ik}(0)$ = initial on-board for occupation/level state i, social class k

$X_i(0)$ = initial on-board for occupation/level state i

f(t) = overall proportionality factor for time t, equal to the ratio of the overall Navy manpower requirements for year t to the actual population on-board at the base year.

B = base year (corresponding to t=0)

P_{ik} = final goal for occupation/level state i, social class k, expressed as a proportion of the total for state i.

Y_{ik} = year final goal for occupation/level state i, social class k must be met.

Then,

$$X_{ik}(t) = f(t) \cdot \left(X_{ik}(0) + \frac{t}{Y_{ik}-B}\left[P_{ik}X_i(0) - X_{ik}(0)\right]\right), \text{ that is,}$$

$$X_{2/3,2}(5) = .97987251\ \left(340 + \frac{5}{81-76}\left[.02900 \cdot 16867 - 340\right]\right)$$

$$X_{2/3,2}(5) = 479.$$

The supply of individuals of a particular social group, in a particular occupation career level, at a particular point in time, is a function of both the composition of the labor force at that point in time, and the demographic profile of the individuals in the social group. To determine the make-up of the labor pool, projections made on the basis of Bureau of the Census total population figures and National Bureau of Economic Research (NBER) labor force statistics are made.[1/] Since the initial goal setting procedure was to be done for the period ending in 1981, labor force projections were compiled on the basis of 1970 Census Bureau and 1976 NBER figures for 1981. These projections, provided in Figure 2, are stated as percent of the population for each of the eight social groups considered in this study and demonstrate full representation of minorities. Inherent in the calculation of these numbers is the assumption that 45% of the labor force will be female by 1981. These percentages apply to jobs requiring educational attainment and experience that matches the average found in the population.

Negro Male	5.775
Negro Female	4.725
Spanish Speaking Male	2.5025
Spanish Speaking Female	2.0475
Other Male	1.0725
Other Female	0.8775
White Male	45.65
White Female	37.35

Figure 2

1/ See Gastwirth and Haber [10] for a discussion of possible methodology.

For certain occupations, such as those falling in the Scientists and Engineers category, educational/experience requirements are such that the minority and female components of the population can not reach full representation. To be consistent with the supply constraints that thereby exist in occupations of this type, allowances are made in the labor market statistics during the labor market analysis phase of the goal setting procedure. For the Scientists and Engineers category the allowances in full representation take the form of providing that by 1981, women will comprise 5% of the workforce and minority males will make-up 7% of the workforce.

The labor market analysis phase also incorporates affirmative action input in the calculation of the supply ratios. Such information provides insight into the degree of imbalance that exists currently for any occupation and set of social groups by comparing actual representation of the social groups on-board across occupation groups and the full representation figures. One example of these affirmative action considerations is a determination of the length of time it might reasonably take to achieve the representation defined via the supply constraints. Another example is the fact that in some occupational levels, certain social groups are already over-represented. In both cases it is infeasible to meet the strictly desired EEO representation, since it would require drastic reductions in the number of employees found in these categories. The EEO policies are indicated by the model as results which illustrate affirmative action alternatives that could be developed to make up the difference between labor market availability and population representation.

In addition to the goal setting procedure described above, lower bounds can be specified as another input to the model. This was not done

in the preliminary prototype studies described in [1], but now the lower bounds on the occupation level - social states force the model to have at least as many people of each social group in these states as indicated by the level prescribed by those bounds. For the cases where the lower bounds calculated from Federal workforce data were higher than the goal, the lower bound was set to equal the goal. This ensures that the setting of the lower bounds is not building discriminatory biases into the resulting policies.

Upward Mobility and the Flexibility Model

In addition to making the goals realistic from the labor market point of view, a comprehensive EEO program must consider affirmative action policies for the internal staff. The limited version of the EEO model tested and described in [1], provided a mechanism for recruitment adjustments. It did not provide for the evaluation of changes to the internal movement rates. Thus, the information concerning the creation of "bridge" or upward mobility positions was only implicitly included in the final results. The complete EEO model structure described in [3], allows for the explicit enumeration of these "flexible" changes. It was decided that the next step in the research would be to develop a numerical example with Navy data which included these flexibility extensions.

The objectives of the flexibility model prototype study were two-fold. First, it was desired to learn whether the type of model coefficients required could actually be obtained in the context of operational data. Second, the prototype would provide insight into the computer support requirements, particularly in reference to model size. This information could be then used to determine the strategy of further work along these lines.

The flexibility extension to the EEO model permits the explicit examination of additional and/or fewer movements of personnel within a given occupation group than historically expected. The additive and subtractive flexibility allowed by the model indicates where and how promotion policy must be changed to meet both long and short range goals of the organization. This in turn provides the information needed on how many "bridge" positions ought to be established.

Bridge positions, loosely defined, are established positions which allow employees to move from dead-end positions or other occupations to those which are career enhancing and have promotional opportunities. While in a "bridge position" status, the employee will have drawn up a development plan that includes training, both on-the-job and in the classroom, and evaluation procedures to insure that his performance will match the needs of the organization. The establishment of bridge positions is an official Navy policy [12], which serves to enhance both staffing flexibilities and employee development and utilization. It can be used as a method of promoting upward mobility that retains the merit promotion system aspects of staffing policy.

The mathematics of the EEO flexibility model were provided in [3]. In this paper we will provide a description of each of the model's inputs and outputs (summarized in Figure 3) in the context of our numerical example. This will be followed by a comparison of running versions of the model with and without the flexibility features.

Because of the model's formulation, we are able simultaneously to consider two sets of objectives or goals. The Total Manpower Goals deal

INPUT CHART

VARIABLE	DESCRIPTION
Manpower Requirements	The number of individuals across social groups necessary in each job category to meet the operating needs of the organization.
Proportional Requirements	The number of minority individuals, by occupation group, desired to be on-board to match their representation in the labor force.
Minimum EEO Proportions	The proportional lower bounds allowed by job category and social group on the number of minority personnel by occupation group.
Initial Population	The number of personnel of each social group on-board in each job category at the start of the transition period.
Historical Transition Rates	The rates of movement between specific occupation groups, based on the analysis of such movements over time.
Priorities for Goal Attainment	A representation of the "costs" associated with not meeting the total manpower goals and the proportional EEO goals.
Priorities for Hiring and Firing	A representation of the "costs" associated with hiring personnel into jobs from outside the system, and with firing personnel.
Flexibility Policy	The degree of flexibility allowed in the system . . . policy parameter.

OUTPUT CHART

VARIABLE	DESCRIPTION
On-board Personnel	The number, by social group and job category, of personnel at the end of each transition period . . . workforce composition.
Hires and Fires	The number of personnel, by social group and job category, hired and fired during the transition period.
Inter-Occupational Mobility	The job mobility, including that beyond historical rates, suggested to meet goals as a function of flexibility.
Goal Discrepancies	How well each goal (total and proportional), for each occupation group, is met.

The two charts above show the elements of informations necessary to run the EEO flexibility model, and the components of the model's solution.

Figure 3

10

with satisfying the operating needs of the organization in terms of workload manpower requirements. The issue of changing the personnel mix to conform with EEO policy is provided for by the Proportional Manpower Goals. These goals set targets for the fractional part of the total manpower requirements desired for each social category. The objective of the model is to minimize the differences between these two sets of goals subject to various constraints. Since a worked-out example with hypothetical data exists in [3], we will limit our discussion to the flexibility part of the model.

Figures 4a and 4b are the transition matrices for the male and female groups. The diagonal cell entries indicate the proportion of personnel remaining in the job category in which they started. Off-diagonal elements show the transfer rates between any two jobs (e.g., the transfer rate for female personnel from Administrative jobs at the GS 9-12 level to jobs in the Technical occupation group at the GS 9-12 level is .004). No entry in a cell signifies an historical transfer rate close to or equal to zero.

Flexibility is expressed as changes to the unadjusted organizational transition matrices. This is accounted for in the model by setting up equations which permit either additions to or subtractions from the unadjusted transition rates. These changes are controlled by coefficients. In the case of additions, they are policy parameters (or the maximum amount the organization is willing to let the model seek an adjusted transition matrix). In the case of subtractions, the controls are set so that the number of transfers can not exceed the number available for transfer. These flexibility constraints are further controlled by a set of equations which ensures that the number of additions will equal the number of subtractions, for any selected job and level.

MALE MATRIX

F / T	A1	A2	A3	A4	T1	T2	T3	T4	C1	C2	C3
A1	.238				z				z		
A2	.095	.556			z	$.013_z$			$.007_z$	$.031_z$	
A3		.311	.874			$.016_z$	$.030_z$			$.003_z$	$.146_z$
A4			.013	.863			z	$.051_z$			$.008_z$
T1	z				.453				$.014_z$		
T2	z	$.016_z$			.286	.756			$.016_z$	$.067_z$	
T3		$.005_z$	$.009_z$			.107	.893			$.002_z$	$.051_z$
T4			z	$.001_z$			.001	.841			z
C1	z				$.018_z$				$.680_z$		
C2	$.047_z$	$.004_z$			$.003_z$	$.003_z$			.068	.764	
C3		z	z			z	z			.002	.698

a

FEMALE MATRIX

F / T	A1	A2	A3	A4	T1	T2	T3	T4	C1	C2	C3
A1	.533				z				z		
A2	.200	.634			$.004_z$	$.018_z$			$.003_z$	$.018_z$	
A3		.212	.891			$.015_z$	$.096_z$			$.001_z$	$.057_z$
A4			.006	.868			$.001_z$	z			z
T1	z				.628				$.011_z$		
T2	z	$.033_z$			.120	.812			$.007_z$	$.034_z$	
T3		$.004_z$	$.004_z$			.024	.800			z	$.021_z$
T4			z	z			.001	1.0			z
C1	z				$.052_z$				.695		
C2	z	$.014_z$			$.013_z$	$.020_z$			.084	.819	
C3		z	z			z	$.002_z$			.001	.784

b

Transition Matrices for Promotions or Lateral Transfers, and Upward Mobility in the Administrative, Technical, and Clerical Occupation Groups Across GS-Levels.

Occupation Groups

A = Administrative Jobs
T = Technical Jobs
C = Clerical Jobs

Levels

1 = GS 1-4
2 = GS 5-8
3 = GS 9-12
4 = GS 13-15

Key

= invalid transition, due to Federal System's structure

= transition not allowed in this model . . . not representative of a promotion or lateral transfer

z = allowable "flexible" transition

Figure 4

The flexibility feature provides a method to evaluate the increase or decrease in the number of individuals entering specific occupation groups from other job categories. Since the same coefficients are used for all social categories (i.e., race-sex combinations), the Merit Promotion System is preserved. Thus, the method allows for the achievement of desired alternatives in the projected steady-state probabilities from their historical values.

For the numerical example the model was run both with and without the flexibility options. A three period example was developed using data representative of the probable size and structure of the Navy civilian white collar administrative, technical, and clerical occupations for the three years starting in March 1976. Two levels of flexibility options were tested (i.e., 100% of all available personnel at the start of each period, and 50% of all available personnel at the start of each period). The maximum subtractive flexibilities were set to equal the transition rates given in Figure 4 so that the total amount of movement in the system would not be greater than normally experienced. The weights were set 15, 10, and 5 for each of the periods respectively for the workload goals and 5, 10, and 15 for the EEO goals. This was done to indicate that workload should be considered relatively more in the short run and EEO relatively more in the longer run. Hiring weights were set at 3 and firing weights were set at 1000. This ensured that internal movements were preferred to hiring and firing was an extreme last resort.

It was found in the solutions that the addition of the flexibility constraints did produce different results. The two different levels of flexibility produced exactly the same results. This indicates that the number of people possible for an internal assignment is below the levels set in the tests. The results for the example without flexibilities are given in Figures 5a, b, and c and the results for the two examples with flexibilities are given in Figures 6a, b, c, d, and e.

In all the cases the total manpower goals are met exactly in the first and second time periods, while discrepancies from total goals exist in the third time period. Many of the discrepancies are the same for particular

EEO MODEL SOLUTION

PERSONNEL TYPE AND OCCPATION GROUP/LEVEL	ABOARD	HIRES	RIF'S	PROPORTIONAL		TOTAL	
				GOAL	DISCREP.	GOAL	DISCREP.
MALE ADM LEV 1	13	9	0			35	0
FEMALE ADM LEV 1	23	102	0	23	0		
MALE ADM LEV 2	1,990	603	0			4,168	0
FEMALE ADM LEV 2	2,178	0	0	2,071	+107*		
MALE ADM LEV 3	15,835	0	0			21,290	0
FEMALE ADM LEV 3	5,455	714	0	5961	-506**		
MALE ADM LEV 4	4,858	0	0			5,627	0
FEMALE ADM LEV 4	769	405	0	844	- 75		
MALE TECH LEV 1	1,057	577	0			3,020	0
FEMALE TECH LEV 1	1,963	336	0	1,963	0		
MALE TECH LEV 2	7,210	799	0			14,294	0
FEMALE TECH LEV 2	7,084	0	0	6,561	+523		
MALE TECH LEV 3	15,826	794	0			17,604	0
FEMALE TECH LEV 3	1,778	1	0	2,641	-863		
MALE TECH LEV 4	357	31	0			391	0
FEMALE TECH LEV 4	34	0	0	27	+ 7		
MALE CLER LEV 1	6,522	3,483	0			32,609	0
FEMALE CLER LEV 1	26,087	6,404	0	26,087	0		
MALE CLER LEV 2	6,236	3,580	0			39,196	0
FEMALE CLER LEV 2	33,160	819	0	33,487	-327		
MALE CLER LEV 3	116	27	0			281	0
FEMALE CLER LEV 3	165	0	0	161	+ 4		

The solution for the First Time Period for the EEO Model Without Flexibility Constraints

* ABOARD - GOAL = 2178-2071 = +107 (over achievement of goal)
** ABOARD - GOAL = 5455-5961 = -506 (under achievement of goal)

Figure 5a

EEO MODEL SOLUTION

PERSONNEL TYPE AND OCCPATION GROUP/LEVEL	ABOARD	HIRES	RIF'S	PROPORTIONAL		TOTAL	
				GOAL	DISCREP.	GOAL	DISCREP.
MALE ADM LEV 1	14	11	0			35	0
FEMALE ADM LEV 1	21	9	0	21	0		
MALE ADM LEV 2	2,005	565	0			4,201	0
FEMALE ADM LEV 2	2,196	0	0	2,100	+ 96*		
MALE ADM LEV 3	15,085	0	0			21,457	0
FEMALE ADM LEV 3	6,372	734	0	7,081	- 709**		
MALE ADM LEV 4	4,417	0	0			5,427	0
FEMALE ADM LEV 4	1,010	308	0	1,357	- 347		
MALE TECH LEV 1	1,208	638	0			3,021	0
FEMALE TECH LEV 1	1,813	293	0	1,813	0		
MALE TECH LEV 2	6,930	623	0			14,300	0
FEMALE TECH LEV 2	7,370	0	0	7,150	+ 220		
MALE TECH LEV 3	15,075	0	0			17,611	0
FEMALE TECH LEV 3	2,536	910	0	4,403	-1,867		
MALE TECH LEV 4	321	0	0			377	0
FEMALE TECH LEV 4	56	20	0	56	0		
MALE CLER LEV 1	9,783	5,329	0			32,609	0
FEMALE CLER LEV 1	22,826	4,593	0	22,826	0		
MALE CLER LEV 2	9,849	4,608	0			39,396	0
FEMALE CLER LEV 2	29,547	0	0	29,547	0		
MALE CLER LEV 3	115	22	0			281	0
FEMALE CLER LEV 3	166	0	0	155	+ 11		

The solution for the Second Time Period for the EEO Model without Flexibility Constraints

* ABOARD - GOAL = 2196-2100 = + 96 (over achievement of goal)
** ABOARD - GOAL = 6372-7081 = -709 (under achievement of goal)

Figur

EEO MODEL SOLUTION

PERSONNEL TYPE AND OCCPATION GROUP/LEVEL	ABOARD	HIRES	RIF'S	PROPORTIONAL		TOTAL	
				GOAL	DISCREP.	GOAL	DISCREP.
MALE ADM LEV 1	18	15	0			36	0
FEMALE ADM LEV 1	18	7	0	18	0		
MALE ADM LEV 2	1,580	0	0			4,242	- 525**
FEMALE ADM LEV 2	2,137	0	0	2,121	+ 16*		
MALE ADM LEV 3	14,417	0	0			21,671	+1,414
FEMALE ADM LEV 3	8,668	2,132	0	8,668	0		
MALE ADM LEV 4	4,026	0	0			5,167	+ 409
FEMALE ADM LEV 4	1,550	633	0	1,550	0		
MALE TECH LEV 1	1,511	827	0			3,023	0
FEMALE TECH LEV 1	1,512	122	0	1,512	0		
MALE TECH LEV 2	6,868	435	0			14,307	0
FEMALE TECH LEV 2	7,439	0	0	7,154	+285		
MALE TECH LEV 3	14,375	0	0			17,620	+2,922
FEMALE TECH LEV 3	6,167	3,924	0	6,167	0		
MALE TECH LEV 4	289	0	0			359	+ 2
FEMALE TECH LEV 4	72	13	0	72	0		
MALE CLER LEV 1	7,195	521	0			32,609	-4,218
FEMALE CLER LEV 1	21,196	5,238	0	21,196	0		
MALE CLER LEV 2	13,078	4,855	0			39,396	0
FEMALE CLER LEV 2	26,318	0	0	25,607	+711		
MALE CLER LEV 3	116	16	0			281	0
FEMALE CLER LEV 3	164	0	0	141	+ 24		

The solution for the Third Time Period for the EEO Model without Flexibility Constraints

* ABOARD - GOAL = 2137-2121 = +16 (over achievement of goal)
** ABOARD - GOAL = (1580+2137)-4242 = -525 (under achievement of goal)

Figure 5c

EEO MODEL SOLUTION

PERSONNEL TYPE AND OCCPATION GROUP/LEVEL	ABOARD	HIRES	RIF'S	PROPORTIONAL		TOTAL	
				GOAL	DISCREP.	GOAL	DISCREP.
MALE ADM LEV 1	12	8	0			35	0
FEMALE ADM LEV 1	23	5	0	23	0		
MALE ADM LEV 2	1,990	0	0			4,168	0
FEMALE ADM LEV 2	2,178	0	0	2,071	+107*		
MALE ADM LEV 3	15,835	0	0			21,290	0
FEMALE ADM LEV 3	5,455	687	0	5,961	-506**		
MALE ADM LEV 4	4,858	0	0			5,627	0
FEMALE ADM LEV 4	769	405	0	844	- 75		
MALE TECH LEV 1	1,057	313	0			3,020	0
FEMALE TECH LEV 1	1,963	85	0	1,963	0		
MALE TECH LEV 2	7,210	0	0			14,294	0
FEMALE TECH LEV 2	7,084	0	0	6,561	+523		
MALE TECH LEV 3	15,826	0	0			17,604	0
FEMALE TECH LEV 3	1,778	793	0	2,641	-863		
MALE TECH LEV 4	357	1	0			391	0
FEMALE TECH LEV 4	34	31	0	27	+ 7		
MALE CLER LEV 1	6,522	3,181	0			32,609	0
FEMALE CLER LEV 1	26,087	0	0	26,087	0		
MALE CLER LEV 2	5,909	3,255	0			39,396	0
FEMALE CLER LEV 2	33,487	1,110	0	33,487	0		
MALE CLER LEV 3	116	27	0			281	0
FEMALE CLER LEV 3	165	0	0	161	+ 4		

The solution for the First Time Period for the EEO Model, including Flexibility Constraints, where Flexibility is set both for 100% and for 50% of the Available Personnel.

* ABOARD - GOAL = 2178-2071 = +107 (over achievement of goal)

** ABOARD - GOAL = 5455-5961 = -506 (under achievement of goal)

Figure 6a

EEO MODEL SOLUTION

PERSONNEL TYPE AND OCCPATION GROUP/LEVEL	ABOARD	HIRES	RIF'S	PROPORTIONAL		TOTAL	
				GOAL	DISCREP.	GOAL	DISCREP.
MALE ADM LEV 1	14	10	0			35	0
FEMALE ADM LEV 1	21	4	0	21	0		
MALE ADM LEV 2	1,999	0	0			4,201	0
FEMALE ADM LEV 2	2,202	0	0	2,100	+ 102*		
MALE ADM LEV 3	15,084	0	0			21,457	0
FEMALE ADM LEV 3	6,373	699	0	7,081	- 708**		
MALE ADM LEV 4	4,417	0	0			5,427	0
FEMALE ADM LEV 4	1,010	308	0	1,357	- 347		
MALE TECH LEV 1	1,208	336	0			3,021	0
FEMALE TECH LEV 1	1,813	58	0	1,813	0		
MALE TECH LEV 2	6,919	0	0			14,300	0
FEMALE TECH LEV 2	7,381	0	0	7,150	+ 231		
MALE TECH LEV 3	15,075	0	0			17,611	0
FEMALE TECH LEV 3	2,536	909	0	4,403	-1,867		
MALE TECH LEV 4	321	0	0			377	0
FEMALE TECH LEV 4	56	20	0	56	0		
MALE CLER LEV 1	9,783	4,886	0			32,609	0
FEMALE CLER LEV 1	22,826	2,402	0	22,826	0		
MALE CLER LEV 2	10,718	0	0			39,396	0
FEMALE CLER LEV 2	28,678	4,545	0	29,547	- 869		
MALE CLER LEV 3	115	22	0			281	0
FEMALE CLER LEV 3	166	0	0	155	+ 11		

The solution for the Second Time Period for the EEO Model, including Flexibility Constraints, where Flexibility is set both for 100% and for 50% of the Available Personnel.

* ABOARD - GOAL = 2202-2100 = +102 (over achievement of goal)
** ABOARD - GOAL = 6373-7081 = -708 (under achievement of goal)

Figure 6b

PERSONNEL TYPE AND OCCPATION GROUP/LEVEL	ABOARD	HIRES	RIP'S	PROPORTIONAL		TOTAL	
				GOAL	DISCREP.	GOAL	DISCREP.
MALE ADM LEV 1	18	13	0			36	0
FEMALE ADM LEV 1	18	3	0	18	0		
MALE ADM LEV 2	2,117	0	0			4,242	0
FEMALE ADM LEV 2	2,125	0	0	2,121	+ 4*		
MALE ADM LEV 3	14,417	0	0			21,671	+1,414
FEMALE ADM LEV 3	8,668	2,092	0	8,668	0		
MALE ADM LEV 4	4,026	0	0			5,167	+ 409
FEMALE ADM LEV 4	1,550	633	0	1,550	0		
MALE TECH LEV 1	1,030	0	0			3,023	- 481**
FEMALE TECH LEV 1	1,512	0	0	1,512	0		
MALE TECH LEV 2	6,889	0	0			14,307	0
FEMALE TECH LEV 2	7,418	0	0	7,154	+264		
MALE TECH LEV 3	14,375	0	0			17,620	+2,922
FEMALE TECH LEV 3	6,167	3,920	0	6,167	0		
MALE TECH LEV 4	289	0	0			359	+ 2
FEMALE TECH LEV 4	72	13	0	72	0		
MALE CLER LEV 1	11,413	4,074	0			32,609	0
FEMALE CLER LEV 1	21,196	3,320	0	21,196	0		
MALE CLER LEV 2	9,527	641	0			39,396	-4,262
FEMALE CLER LEV 2	25,607	0	0	25,607	0		
MALE CLER LEV 3	117	0	0			281	0
FEMALE CLER LEV 3	164	0	0	141	+ 23		

The solution for the Third Time Period for the EEO Model, including Flexibility Constraints, where Flexibility is set both for 100% and for 50% of the Available Personnel.

* ABOARD - GOAL = 2125-2121 = +4 (over achievement of goal)

** ABOARD - GOAL = (1030+1512)-3023 = -481 (under achievement of goal)

Figure 6o

EEO MODEL SOLUTION

1st Time Period

F / T	A1	A2	A3	A4	T1	T2	T3	T4	C1	C2	C3
A1											
A2	-1										
A3		-603*									
A4											
T1									+302		
T2					-264					+6	
T3		+603**				-799					
T4											
C1	+1				+264						
C2						+799			-302		
C3										-6	

2nd Time Period

F / T	A1	A2	A3	A4	T1	T2	T3	T4	C1	C2	C3
A1									+443		
A2	-1					+634					
A3		-569									
A4											
T1											
T2					-302					+12	
T3						-634					
T4											
C1	+1										
C2		+569			+302				-443		
C3										-12	

3rd Time Period

F / T	A1	A2	A3	A4	T1	T2	T3	T4	C1	C2	C3
A1									+665		
A2	-1										
A3		-514				+406					
A4											
T1	+1										
T2					-345					+15	
T3						-406					
T4											
C1					+345						
C2									-665		
C3		+514								-15	

Flexible Transfers for Males for each of the Three Time Periods

* -603 = Those who do not transit from Job A2 to A3 in the First Time Period, who were historically expected to make that move.

** +603 = Those who additionally transit from Job A2 to A3 in the First Time Period, above those who were historically expected to make that move.

KEY

A1 Administrative, Level 1
A2 Administrative, Level 2
A3 Administrative, Level 3
A4 Administrative, Level 4
T1 Technicians, Level 1
T2 Technicians, Level 2
T3 Technicians, Level 3
T4 Technicians, Level 4
C1 Clerical, Level 1
C2 Clerical, Level 2
C3 Clerical, Level 3

Figures 6d

EEO MODEL SOLUTION

1st Time Period

F / T	A1	A2	A3	A4	T1	T2	T3	T4	C1	C2	C3
A1											
A2	-5								+6,404	+36	
A3											
A4			-27*								
T1											
T2					-252						
T3											
T4							-1				
C1	+5				+252				-6,404		
C2											
C3			+27**				+1			-36	

2nd Time Period

F / T	A1	A2	A3	A4	T1	T2	T3	T4	C1	C2	C3
A1									+2,191		
A2	-5										
A3			-2,427								
A4			- 33				+2				
T1											
T2					-236					+5,714	
T3			+2,460								
T4							-2				
C1	+5				+236						
C2									-2,191	-5,681	
C3										- 33	

3rd Time Period

F / T	A1	A2	A3	A4	T1	T2	T3	T4	C1	C2	C3
A1											
A2	-4										
A3											+72
A4			-38				+3				
T1											
T2					-122				+1,917		
T3											
T4							-3				
C1	+4				+122						
C2									-1,917		
C3			+38								-72

Flexible Transfers for Females for each of the Three Time Periods

* -27 = Those who do not transit from Job A3 to A4 in the First Time Period, who were historically expected to make that move.

** +27 = Those who additionally transit from Job A3 to C3 in the First Time Period, above those who were historically expected to make that move.

KEY

A1 Administrative, Level 1
A2 Administrative, Level 2
A3 Administrative, Level 3
A4 Administrative, Level 4
T1 Technicians, Level 1
T2 Technicians, Level 2
T3 Technicians, Level 3
T4 Technicians, Level 4
C1 Clerical, Level 1
C2 Clerical, Level 2
C3 Clerical, Level 3

jobs and levels in both the solutions employing flexibility options and the one without flexibility options. This is the case, for instance, in the Technicians category, for levels 2, 3, and 4, where discrepancies are 0, +2922, and +2, respectively. However, in other cells of the solutions, very definite differences exist. One notable example occurs in the first level Technicians group, where the solution for the model without flexibilities indicates no discrepancy from the total goal, and the flexibility solutions show a discrepancy of -481 from the total goal. This might seem to indicate that the model with the flexibility options included provides a less desirable set of outcomes. However, a further comparison of solution results shows that although for some jobs and levels the outcomes are worse, for others the outcomes are considerably better. This is the case for second level Administrative positions, where the discrepancy from the total goals is -525 in the non-flexible solution, and 0 in the flexible ones. Thus, trade-offs are apparent in the internal structure of the organization, and via the inclusion of the flexibility options, these trade-off possibilities become feasible decision-making alternatives. Similarly, significant trade-offs between internal transfers and outside hiring become initially visible through a comparison of the discrepancies from the EEO goals in the cases with and without the flexibility constraints. In these sets of data both the goal fulfillment and the internal staffing patterns changed. In some earlier test examples the addition of the flexibility constraints did not matter as far as changing the overall EEO distributions. Further research would have to be done with a problem approximating the time periods used in actual planning to determine under what conditions the addition of the flexibility constraints would improve the overall EEO distributions.

The data on model sizes and computer running times were examined to obtain information to assist in the implementation strategy. These statistics are given in Figure 7. As can be seen, the flexibility model is considerably larger in size and computer processing time. The computation times are on a UNIVAC 1108 computer and include the use of an advanced start by means of a previous optimal basis. A minimum practical problem is most likely to contain 5 time periods, 8 race-sex categories and 30 occupation-level categories. A model without the flexibilities used in actual operational studies contains 2796 rows and 6540 columns and solves in 34 CPU minutes starting with an advanced basis on the UNIVAC 1108 using 67K of main memory. This model extended to include the flexibility constraints can be expected to be approximately 7500 rows and 12,000 columns. Its solution time would require somewhere in the neighborhood of 8-10 CPU hours using a UNIVAC 1108 with 120K of main memory.

Computer: UNIVAC 1108

	Without Flexibility Constraints	With Flexibility Constraints
Rows	158	404
Columns	352	688
CPU Time	0:00:13.252	0:01:06.985
Memory Time*	0:00:35.747	0:03:21.117

Problem: 3 time periods; 2 race-sex categories; 11 occupation-level categories

*Memory time is a measure of the impact of the processing job on the computer system.

Figure 7

Extensions and Future Research

The goal of the Department of the Navy is to attract all people with ability, dedication, and capacity for growth. In pursuit of that objective Presidential, Congressional, and Department of Defense mandates require that we provide equality of opportunity for minorities and women throughout the entire Naval structure. Therefore, a managerial system which enables the logical determination of goals for minorities and women is a prerequisite to the achievement of an "Equal Opportunity Employer" status. Further, that management system must also provide a means whereby policy makers can determine whether or not the goals are attained. This system, initially discussed in [1], provides that kind of accountability.

Since subordinate levels of command play a significant role in carrying out policies ennunciated by top management, this system must eventually be developed to address the local/regional level of goal-setting and analysis. These local/regional areas will be defined by Standard Metropolitan Statistical Areas (SMSA's) or equivalent geographic distinctions which are appropriate to the occupations concerned. That is, affirmative action programs are best developed and implemented at the local/regional level since policies must be designed to address local problem areas many of which are a function of the necessity for regional recruitment in occupations such as Technicians and Clerks.

Currently, the goal-setting procedures we have developed are appropriate for the larger-scale aggregate analysis. Extended labor market research is underway to investigate regional goal-setting situations. Among the issues encountered in this research is the problem of small cell size due to the need to partition data on several attributes to match the EEO designations. This same problem is also encountered when studying upward mobility considera-

tions in terms of "flexibility". The coherence model discussed in [2] is being designed to overcome this small cell size problem, especially in terms of the flexibility issue. In addition, since the current flexibility model development results in a somewhat unwieldy system advances in the study of flexibility and affirmative action via the coherence model is warranted. A first step in this direction is a prototype study that links the current EEO model and control system to the regional level of analysis by using the coherence model framework.

Personnel data on the Navy Department's civilian manpower pool is presently being analyzed for this linkage study. More labor market information is necessary to carry on this work. Much data of this kind may be available through sources such as data bank files Bureau of Labor Statistics and the U. S. Census manpower data base distributed by the National Technical Information Service of the Department of Commerce. These data bases which can be provided on magnetic tape will have to be closely investigated to determine how to best develop affirmative action policy-making mechanisms at the local level.

In addition, the model must be immediately extended to the blue-collar workforce. This is particularly true for the Navy since half of its workforce is blue collar. The labor market studies in this case would be consistent with the prevailing wage setting areas.

The flexibility features are an important addition to the goal programming models for manpower planning. Without the EEO categories, their size diminishes by a factor of eight. At this more compact size, they could be used as the master model linked to the coherence model which contains all the needed EEO features. The main difficulty may be the proper feedback

mechanisms to prevent oscillation. This arrangement would also ensure that the basic strategic staffing decisions are made within the merit system and still be integrally linked to the kinds of decisions necessary for taking into account equal employment opportunities. The alternate to this would be to use a master model without the flexibility features but with the EEO categorizations included. This is the subject of further research.

The results provided in this report are being used to develop the design for the initial version of a comprehensive operational information system. This system is being designed to be able to process 30-50 models all integrated into the same forecast with all processing completed within a two week time frame using 30 CPU minutes or less on a UNIVAC 1108 for solution of each of the models plus the necessary input/output processing. The possibility of adding the flexibility constraints will be preserved in the variable naming conventions. However, the initial system will use the version of the model without the flexibility constraints. In this way all the options are preserved in the implementation.

The initial study of the demographic and upward mobility additions to the EEO model provided insight into the critical elements of goal setting and internal staffing possibilities. The next step is the development of the support capabilities including the incorporation of regional labor market studies. These results are useful not only for EEO considerations but also for resolution of many of the general issues of integrating manpower planning with its data sources and personnel decision-making possibilities.

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This paper extends previous numerical results of the EEO goal programming model developed by Charnes, Cooper, Lewis and Niehaus. One purpose is to document in more detail the EEO goal-setting procedures. Another is to provide an initial numerical example with actual Navy data of the extended version of the model which includes flexibility features. In this version the internal promotion and upward mobility considerations can be evaluated explicitly. With the extended prototype in hand, a discussion is provided of the implementation and continuing research possibilities.